Workshop on Aquaculture Research and Development in Canada

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Fisheries and Marine Service
Technical Report 750
January 1978

WORKSHOP ON AQUACULTURE RESEARCH AND DEVELOPMENT IN CANADA

Proceedings of a Workshop held at the
Freshwater Institute
November 29-30, 1977

edited by

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* Reproduced in microfiche.

ABSTRACT

Ayles, G.B. and J.R. Brett. 1978. Workshop on aquaculture research and development in Canada. Can. Fish. Mar. Serv. Tech. Rep. 107: iv + 14 + A1-4 + B1-2p. + microfiche appendices.

This is a report of the proceedings of a workshop conference on biological aspects of aquaculture research and development in Canada, held at the Freshwater Institute, Winnipeg, November 29-30, 1977.

The purpose of the workshop was to improve communication between researchers and to identify research priorities. Pre-conference statements on the aquaculture production in each region and summaries of present research and development were submitted. Areas in need of biological research and development were evaluated. The proceedings include summaries and rapporterus' reports of each of the sessions, and of the pre-conference statements and the recommendations that were an outcome of the workshop.

Key words: aquaculture; aquaculture production.

RESUME

Ayles, G.B. and J.R. Brett. 1978. Workshop on aquaculture research and development in Canada. Can. Fish. Mar. Serv. Tech. Rep. 107: iv + 14 + A1-4 + B1-2p. + microfiche appendices.

Le présent rapport fait le compte rendu de la conférence sur les aspects biologiques de la recherche et du développement en aquaculture, qui s'est tenue à l'institut des eaux douces de Winnipeg, les 29 et 30 Novembre, 1977.

La conférence avait pour but d'améliorer la communication entre les chercheurs et d'établir les priorités de la recherche. On y a présenté les rapports antérieurs à la conférence sur la production aquicole de chaque région ainsi que le sommaire des présents programmes de recherche et de développement. Les secteurs qui doivent être développés et où le besoin de recherches en biologie presse ont fait l'objet d'un examen. Le compte rendu comprend des résumés, les rapports des responsables de chaque séance et ceux d'avant la conférence, ainsi que les recommandations adoptées à cette occasion.

Mots-clefs: aquiculture; production d'aquiculture.

FOREWORD

Aquaculture in Canada is developing rapidly on a regional basis and is likely to have a significant effect on local economies in the near future. Research and development activities have been extensive and have contributed in no small degree to the advances in aquaculture production.

This *ad hoc* Workshop was the first national meeting since 1973 and it was stimulated by a general concern among researchers about the lack of communication and coordination between regions. It was felt that improved communication between working level researchers would assist in the development of aquaculture as a whole as well as the individual research activities. The Workshop was directed toward biological research and development which is only one aspect of the total spectrum of activities related to aquaculture development. Only individuals who were personally involved in research activities attended and the number was restricted in order to facilitate the interchange that develops more easily in a small group. We apologize to those few who should probably have attended but were, in our ignorance, not invited.

The Workshop was planned and chaired by G.B. Ayles, Freshwater Institute, Winnipeg, and J.R. Brett, Pacific Biological Station, Nanaimo. Dr. G.H. Lawler, Director-General, Western Region, Fisheries and Marine Service, and Dr. W.E. Johson, Director-General, Pacific Region, Fisheries and Marine Service, provided encouragement and support for the meeting. The Western Region provided facilities for the meeting at the Freshwater Institute and published these proceedings. J. Mathias, J. Lark, R. Josephson and S. Zettler of the Freshwater Institute provided organizational assistance. M. Smith typed the manuscript.

In order to keep reproduction costs to a minimum the submitted pre-conference statements have been produced in microfiche, a copy of which is supplied with each report. The material has not been retyped and is reproduced as submitted.

INTRODUCTION

The present status of production and advances in research and development of aquaculture[1] in Canada since 1973 (when the first government-industry seminar was held) was reviewed by researchers from industry, university and government. The meeting involved those engaged in biological, technological and educational studies. Socio-economic aspects such as market development, licensing, labor and capital, government policies, etc., are recognized as being of great importance to aquaculture development but were not considered except in a most general way. The meeting was expressly aimed at:

- providing a means of improved communication between aquacultural researchers in different parts of the country in order to maximize cooperative efforts and minimize unnecessary duplication;
- identifying future research and development needs as seen from the perspective of working level researchers in governments, universities and in industry.

Pre-conference statements on the status in each region (Pacific, Prairies, Ontario, Ouebec and Atlantic) and reports on present research and development programs with relevant publications (326 listed) were submitted. In addition, the international contributions of Canadians through the International Development Research Centre was summarized. The two-day meeting reviewed and discussed the essence of these submissions and then proceeded to evaluate (1) the progress made and (2) the areas of greatest need in research and development to further advance Canadian aquaculture.

GENERAL STATEMENT AND SUMMARY OF MEETING

THE NATIONAL OUTLOOK

The natural assets and limitations for success show great regional differences. Seapen rearing of Pacific salmon is a general success story with sustained fish growth through the mild winter months; great need for developing brood stocks for some species exists and research on low-cost diet formulations is pressing. In the prairies rapid summer growth of rainbow trout (coupled with winterkill) and an abundance of natural food in pothole lakes sustains a cottage industry with approximately 4,000 farmers; but lack of cooperative processing and quality control rather than biological problems remain as deterrents to a thriving industry. Some 93 private fish hatcheries in Ontario raise mostly rainbow trout with a small percentage of brook trout and bass; however, disease certification, managerial expertise and improved markets are necessary for expansion. Most of the 72 commercial hatcheries in Quebec raise speckled trout; put-and-take fisheries are increasing. In the Atlantic Region the feed-lot culture of bluefin tuna has created a 3-million-dollar industry, and rainbow trout have been raised to market size in a commercial scale pilot project in the Bras d'Or Lakes. The development of low-cost, heat-saving water reuse systems would significantly enhance the probability of aquaculture success, particularly for ocean ranching of Atlantic salmon operations which require rapid growth in the freshwater phase.

On both coasts the relatively simple techniques of bottom and off-bottom culturing of oysters continues to provide a better product for improved markets. Gradual expansion is occurring; biological and technological equirements for further development are not pressing. Although a pilot plant for lobsters has demonstrated the capacity and know-how for culturing from egg to marketable product, high-cost components of the system mitigate against any early expectation of profitability; however, one breakthrough has come from extending the growth of captive wild stock by glandular removal of the maturation hormones (by eyestalk ablation).

[1] Defined as the culturing of aquatic organisms for sale or use, involving the development and application of animal and plant husbandry.

RESEARCH AND DEVELOPMENT HIGHLIGHTS AND DIRECTION

The culture of aquatic organisms in Canada is based to a large extent on life history studies carried out in the past as part of basic fisheries ecology work. There is still a need for such information for some of the more promising species such as marine macrophytes.

The knowledge gained from studies of environmental physiology (e.g., growth optimization, advanced smolt transformation, oxygen and temperature requirements, density effects) contributes to the design of efficient rearing facilities and offers potential solutions for the seasonal adversities of our northern climate. Likewise, the development of water reuse systems, including the use of solar heat and other innovative forms of energy and resource use offers similar advantages.

The supply of fish for culture operations is a major problem for many species grown in other parts of the world. Fortunately the reproduction of most Canadian cultured fish is possible in a controlled environment and while seed supply is an institutional problem in parts of the country, it is not a biological problem.

Implementation of disease control regulations will have a significant beneficial effect on the losses due to diseases in government and commercial operations. Advances in disease control through the development of effective vaccines and rapid, mass immunization techniques have been a breakthrough of critical importance in the success of seapen rearing of salmonids. Concerted efforts to improve the control of other diseases (especially bacterial kidney disease and furunculosis) are needed, not just by antibiotics and vaccines, but also by developing resistant stocks and minimizing vulnerability from stress.

Although favorable growth can be obtained in most candidate species with available pelletized feeds, many gaps and considerable room for improvement exist. These center particularly on first feeding stages, suitable diets for marine culture, brood stock diets, and some nutritional diseases or unidentified disease-susceptibility. Reduction in cost and full use of Canadian ingredients (grains, fish and meat wastes, etc.) are prime targets which are showing encouraging developments by newly formulated Canadian diets. With the rise in production of marketable fish and the increases in hatchery production, sufficient demand for feeds is becoming attractive for Canadian-based feed mills.

The application of genetics through breeding and selection practices has already shown some promise (increased growth rates, stock domestication improvement). All across the country there is growing activity in this area. The presence of many races within species of salmonids and their inter-fertility are natural assets within the Canadian scene. Care should be taken to preserve the many small populations which contain the genetic diversity necessary for future genetic improvement.

In the long run, a combination of environmental, physiological, nutritional, hormonal and genetic manipulation of a complete aquaculture system in an interdisciplinary effort holds tremendous potential for biological advance.

The establishment of pilot-scale operations is necessary for the evaluation of factors such as economics, marketing, labor supply, etc. for an aquaculture operation.

Species potential (general priorization by commercial interest)

Fin fish:	Rainbow trout	- greatest freshwater potential with increasing marine use (steelhead race)
	Coho salmon	- greatest marine potential (exotic on U.S. Atlantic coast)
	Chinook salmon	- equal potential to coho but egg availability low
	Brook trout	- favorable in central and eastern Canada
	Atlantic salmon	- slow freshwater growth; ocean-ranching potential
	Pink salmon	- earlier limitations overcome; interest increasing
	Chum salmon	- like pink salmon; a favored ocean-ranching species
Shellfish:	Oysters	- by far the most important on both coasts
	Mussels	- holds considerable potential, but no internal market
	Lobsters	- attracts interest but too marginal in complex rearing
Seaweeds:	Irish moss	- research progressing but no Canadian enterprise yet

GENERAL COMMENTARY

1) National and Regional policy for aquaculture needs reclarification in the light of present status and progress, especially in view of such new policies as the Salmon Enhancement Program, the implementation of the 200-mile limit and the commercialization of ocean-ranching operations on the United States west coast.

2) A central clearing house for information pooling and exchange is desirable to maintain a high level of knowledge flow and avoid unnecessary effort. The use of the office of the national aquaculture coordinator in Ottawa and the production of a semiannual newsletter would be useful.

3) The scientific and technical expertise in Canada is extensive, making substantial contributions to national and international advances and collaborating with other culture programs, such as hatchery operations, sport fish stocking, etc.

4) Education and information exchange in aquaculture is growing. Advanced educational centers have emerged at the university and college level. Films and videotapes have been produced for television and general extension use.

Operating manuals are being prepared for important aquaculture operations.

SESSION A

STATUS OF AQUACULTURE RESEARCH AND DEVELOPMENT PROGRAMS IN CANADA

Summary

Pre-conference statements on present biological research and development programs related to aquaculture in Canada were submitted. Program objectives, personnel and relevant publications were summarized. The submissions from government labs, universities and private corporations represent most but not all of the major aquaculture research and development programs in the country.

Research and development programs have been closely tied to the species and to the problems in each region. Aquaculture research and development activities in the Pacific Region have concentrated on the Pacific salmon. The major activities listed are:

- the design of aquaculture systems and the evolution of an industry infrastructure,
- pilot-scale cage culture of Pacific salmon,
- development of vaccines,
- development of fish disease diagnostic tests,
- diet development and feed manufacturing,
- identification of environmental factors affecting growth, smoltification, etc.,
- control of maturation and reproduction,
- hormonal control of growth,
- development of recirculation systems,
- mollusc culture techniques.

Freshwater aquaculture research is carried out by several different groups working on quite different systems. The major activities are:

- development of pilot-scale pothole trout farming units,
- management techniques for pothole trout farming
- economic studies of pothole trout farming,
- genetic selection of trout in pothole lakes,
- aquatic ecology of fish ponds,
- fish yields in natural systems,
- design of prototype commercial hatcheries,
- computer modeling of aquaculture operations,
- diet formulation and development,
- diet-environment interactions,
- vitamin requirements in diets,
- utilization of regionally produced protein sources in trout diets,
- development of recirculation systems,
- utilization of solar energy,
- development of techniques for diagnostic pathobiology,
- genetics/selective breeding for specific culture systems.

On the Atlantic coast the major research activities are:

- development of culture systems which make better use of energy and resources by means of water reuse and solar heat collectors,
- adaptation of environmentally appropriate technology,
- pilot-scale marine plant cultivation,
- pilot-scale cage culture of rainbow trout,
- mollusc culture techniques,
- growth and physiology of various salmonids in salt water,
- studies of fish diseases of aquatic organisms including furunculosis, bacterial kidney disease of salmonids and Malpeque disease of oysters, Gaffkemis disease of lobsters,
- nutrition of aquatic organisms including tuna, trout, salmon and oysters,
- lobster culture techniques including physiological techniques of growth enhancement, nutrition, etc.,
- stock selection and genetic improvement of Atlantic salmon,
- ocean-ranching of Atlantic salmon.

SESSION B

STATUS OF AQUACULTURE PRODUCTION IN CANADA

Summary

Oysters and salmonids are the dominant organisms in Canadian aquaculture. Oyster production and government production of salmonids have remained relatively constant while non-government commercial production of salmonids has increased by about 10% per year since 1972 and the rate of increase will be even larger in the next few years.

Oysters are produced on both coasts. In 1976 the production was approximately 4100 metric tons live weight with a value of about 2.2 million dollars. Canada produces about 20-30% of the oysters consumed in this country. Implementation of rearing techniques developed and available on both coasts could have a significant effect on production.

The culture of salmonids in Canada has developed on a local basis in accordance with historical and environmental limitations and advantages within each region. On the Pacific coast cage culture of coho and chinook salmon is developing, taking advantage of the warm ocean currents. The natural food produced in previously unutilized pothole lakes is being exploited by the free-ranging culture of rainbow trout in the prairies. In Ontario and Quebec, trout cultured in earthen ponds and raceways are used for recreational fishing and to supply institutional markets in the large cities. In Ontario, rainbow trout are most common while brook trout are favored in Quebec. On the Atlantic coast ocean-ranching of Atlantic salmon offers the most promise but large-scale pilot projects have demonstrated the feasibility of cage culture operations in specific areas such as the Bras d'Or Lakes.

The most recent (1976 and 1977) estimates of salmonid production in the regions are:

	Government[1]	Commercial[1]
Pacific	166,000 kg	75,000 kg
Prairies	59,000 kg	240,000 kg
Ontario	137,000 kg	164,000 kg[2]
Quebec	55,000 kg	167,000 kg[2]
Atlantic	103,000 kg	114,000 kg
Total	520,000 kg	760,000 kg

The commercial or private production of salmonids has risen from about 480,000 kg in 1972, a rate increase of about 10% per year. However, certain types of operations have increased at a much more rapid rate. Prairie pothole trout farming production increased at an average of 25% per year from 1972 to 1976. The production in British Columbia of coho in cages is expected to rise to 100,000 kg in 1978 from only 18,000 kg in 1977, a fivefold increase, and a pilot operation in the Bras d/Or Lakes expects to produce 115,000 kg of rainbow trout in 1977 from virtually nothing in 1976.

Projections of production indicate a rapid rate of increase in the next few years.

SESSION C

AQUACULTURE IN CANADA - WHAT DO WE KNOW?

Pacific: Chairman - E. Donaldson
Rapporteur - D. Groves

Salmon culture

Production of 2,400 lb of market fish in 1974 has now increased to a projected 1,000,000 lb in 1978. Producers have increased in number from 1 in 1973 to 6 in 1978 including 3 private farms and 3 Indian bands.

This rapid growth in the private sector has occurred as a result of advances in the technology and basic biological understanding of salmon production which significantly reduces the risk for capital investment in commercial salmon culture.

Important factors have been the improved formulation of rations and development of local feed manufacturing capabilities as well as advances in the production and application of effective vaccines against marine fish diseases. As a result the prospects for culture of pinks and chum as well as coho and chinook are improved. Husbandry procedures for coho and chinook have developed to a level where the Nanaimo Station achieved a 75% swim-up to market weight survival during the last cycle in coho and chinook.

Size criteria have been refined and the industry is now able to take advantage of the favorable temperature and salinity regimes and shelter available on the British Columbia coast.

Commercial salmon pen culture has progressed to the point where there is confidence that a high quality product can be produced at feasible cost. Further research and development in the areas of nutrition, growth, reproduction, disease prevention, processing and marketing will result in refinements which will improve the economics.

Government aquaculture policy regulating salmon culture has developed with the stimulus of improved culture techniques in British Columbia and the expansion of salmon aquaculture in Puget Sound. Aquaculture policy must be responsive to the requirements of the community which includes the aquaculture industry. Present policy recognizes that aquaculture is an underdeveloped industry.

At the present rate of expansion, growers and government must consider alternatives for brood stock to supply large numbers of eggs. Success of the salmon enhancement program will ensure an adequate supply of "surplus" eggs at government hatcheries in the near future, but eventually holding and spawning of adults in sea pens, sea ranching of brood stocks and other techniques need to be considered. A brood program also allows the possibility of genetic selection.

Increased growth of salmonid aquaculture including the salmon enhancement program will lead to refinement and further development of fish feed manufacturing and to the consideration of new feed ingredient sources. Further coordination and systematization of criteria and procedures for the various licenses and permits will continue to evolve.

At the present level of development, specialization is now feasible and will continue to increase.

Production of salmon smolts by government hatcheries has increased steadily with the stimulation of the salmon enhancement program and its associated research and development.

Sea ranching of Pacific salmon is not presently allowed commercially, but biological information is being accumulated through the operation of the existing government hatcheries and research stations. Developments in Oregon and Alaska are being assessed and will aid in the formulation of necessary regulatory policy should sea ranching be established as a viable and desirable enterprise for the British Columbia coast.

Rainbow trout

Production of trout in freshwater has increased only slowly as compared to salmon culture. This could change since there is increasing interest in the possibilities for trout production in interior ponds irrigation systems, and other privately owned bodies of freshwater.

There is significant potential for rainbow trout production in salt water in British Columbia. A principal constraint is a lack of developed brood stocks within the region, especially since the new

[1] Government production is largely of fingerling size fish (3-20 g) produced for stock enhancement purposes. Commercial production includes only those fish large enough for consumption, not fry or fingerlings.

[2] There are many producers in Ontario and Quebec making it difficult to gather production data. It is believed that these figures are very conservative.

fish health regulations restrict the ease of importing eggs. As a result, there is an opportunity for further development of a regional hatchery/hatcheries for the supply of eggs and fry for lake and salt water culture.

Production in British Columbia government hatcheries is increasing and is now at a level of approximately 9.5 million/year released weight and quality of fry produced is increasing staedily.

There is a potential for the province to supply eggs to aquaculturists in the same manner as the federal government supplies surplus eggs to the salmon aquaculturists.

Oysters

Oyster culture in British Columbia appears to be about to increase again due to the prospects of better marketing procedures and quality control.

Seaweed

There has been increased interest in seaweed harvesting and culture during the past summer. Pilot commercial research and development studies have been initiated at Bamfield on Vancouver Island.

Atlantic: Chairman - J.L. Stewart
Rapporteur - R.E. Drinnan

In his opening remarks, the chairman stated that asking the question, "What do we know?" and attempting to assess the adequacy of the existing technical basis for aquaculture development in the region assumes the prior determination of an appropriate strategy including the species and projects to be supported by technical input. From the earlier review of present and past activities in the Maritimes it might appear that the diversity of activities reflects a desperate attempt to try everything in the hope that something works. However, even though it is unstated and may be largely unconscious, some of the components of a strategy may be determined. Aquaculture is seen largely as a means of creating employment while at the same time assisting the preservation of coastal and maintaining and exploiting a traditional way of life and association with fisheries. Additionally, a number of most favored species can be discussed. This comprises trout, Atlantic salmon, seaweeds, oysters, tuna, lobster and mussels.

In terms of the technical requirements for aquaculture, Pillay's Seed, Feed and Breed covers the essentials.

As underpinnings an adequate knowledge of the following should be included:

- reproduction
- growth of juveniles
- genetics
- nutrition
- physiology
- biochemistry
- disease
- environmental factors,

in essence the full panoply of life sciences!

In addition, there should be consideration of practical measures such as:

1) availability of brood stock and juveniles
2) practical growth strategies (culture systems)
3) coastal zone management
4) participation interest by local people
5) attitudes of local and federal authorities
6) products to be produced
7) marketable aspects
8) involvement by engineers, accountants, economists, etc.
9) relationship of aquaculture to enhancement programs
10) spin-off for ecological work and biological management.

From general discussion of the "state of the art" applicable to the species list suggested, the following emerged:

Trout

1) Freshwater culture

Adequate reliable technology is available. A number of commercial enterprises exist and at least one appears to have been in a viable, even profitable, state for some years. Considerable expertise has been developed in use of recirculated systems, a technology which promises to overcome the major climatic restraints in the region and satisfactory operation of a pilot-scale facility, of unproven economic viability has been accomplished. Both rainbow and brook trout are being reared by both techniques.

2) Marine cage rearing

Satisfactory technology has been demonstrated to the stage of commercial production of *ca* 100 tons of pan-sized fish in the current year. Economic viability has not yet been achieved but is conceivable with relatively minor and credible advances in technology and strategy. The continued growth of fish to larger sizes, though demonstrated to be possible at acceptable risk in specific locations, is generally not a realistic proposition due to the risk of lethal winter water temperatures. Though rainbow trout have been the major species involved, brook trout have been shown to have a similar potential and may, in fact, present some advantages. Establishment of brood stocks and a supply of fingerlings is necessary to develop this potential.

Atlantic salmon

1) Sea ranching - stock enhancement

The technology of rearing smolts for release is well established but of doubtful economic status. Active and promising technological developments are under way.

2) Marine cage rearing

Techniques of rearing post-smolts in marine cages have been demonstrated at pilot commercial scale, but winter conditions make the process a very risky one. As with trout, overwinter holding of fish in marine cages has been generally shown to be an impractical, high-risk procedure and the potential for cage rearing of salmonids in the Maritimes is limited to the spring to fall season.

Seaweeds

True culture of *Chondrus* has a considerable history of development and success. Large experimental or pilot-scale commercial rearing is presently being actively pursued and developed, but factors essential to allow realistic cost projections are still too vague. Cited as present gaps in knowledge were undesirable carbon sources, the metabolic pathways to the end product and the causes of and hence control measures for occasional die-off of cultures.

Native oysters

Our knowledge of the biology and technical requirements for the culture of this species is seen as more than sufficient for support of the present and conceivable very simple culture technology. In fact a good deal of past and present work is at a level of sophistication well in excess of applicability in current economic terms.

Bluefin tuna

An apparently highly successful and lucrative technique of feed-lot culture of adult tuna is presently being practiced at one location. The generated demand for technical input is being adequately met.

Lobsters

1) Egg to market rearing

Biologically feasible techniques have been demonstrated though applicable economics are largely unknown but estimated to be presently disadvantageous. Some significant technical advances are clearly possible. For example, high mortalities at about 6" are common. Developments in feed source of seeds, disease control and engineering design are seen as essential areas of effort.

2) "Grow-on" techniques

The holding and feeding of eyestalk-ablated low-priced smaller commercial-sized lobsters for growth to the more valuable larger sizes has been demonstrated to be biologically feasible and shows great potential for pilot-scale production. The need for attention to the higher feed and oxygen requirements and sensitivity to air exposure of such animals must be accommodated.

Blue mussel

The development of a reliable technology of rearing this species to the level of pilot-scale production and test marketing of a very acceptable range of processed products has been achieved for several years. Economics of commercial-scale operations are as yet unproven and some doubts were expressed about the ability of such products to compete with low-cost offshore competition.

Freshwater: Chairman - S. Slinger
Rapporteur - J. Mathias

Aquaculture in freshwater has developed along more conservative lines than that in salt water. Emphasis has been placed more on refinement of trout farming technology and less on consideration of other species of fish, or invertebrates or algae.

As a result the 'state of the art' is considered relatively advanced, and because of development of the trout industry in the United States, many technologies such as oxygenation equipment, cages, automatic feeders, raceway technology, feeds, and egg and fingerling supplies have been available to Canadian culturists for some time. A further reflection of progress is the trend toward specialization. Viable enterprises now exist in egg and fingerling production, intensive grow-out operations and extensive culture in pothole lakes.

Freshwater aquaculture in Canada can be divided into: government fish stocking programs, commercial "put and take" fisheries, commercial fish farming and pothole trout farming.

Government fish stocking programs are used to enhance commercial or sport fisheries. Walleye, whitefish, pickerel, rainbow trout, lake trout, brook trout, splake, muskellunge, coho, largemouth bass, and smallmouth bass are the major species in order of number of fingerlings produced. There has been increased recognition of the importance of assessing the results of stocking programs and the importance of quality over quantity. Stock enhancement programs have been developed that employ a variety of environmental, economic and social criteria for their assessment. Newly developed biochemical genetic marking techniques offer an innovative method of assessing the results of such programs. Selective breeding has produced fish that grow and mature faster in the wild.

Commercial fish stocking is practiced for private "put and take" recreational use. Advances in technology in other systems can be directly applied to these types of operations which are becoming of increasing importance, especially in Quebec and Ontario.

Commercial fish farming includes egg production, fingerling production and grow-out operations. Rainbow and brook trout are the only species used to a significant degree. About five million of each were raised by private operators to fingerling stage or larger in 1976. Of these, the proportion of rainbow trout increases from 36% in Quebec to 58% in Ontario and 100% in the prairie provinces. Improved diets that are easier to feed, have increased digestibility and use cheaper locally produced components have reduced the relative costs of feed. Imposition of disease control regulations and improved prophylactic techniques such as egg disinfection has significantly reduced disease-related losses.

Rainbow trout are stocked by over 4,000

farmers in eutrophic prairie lakes for recreational and commercial use. Basic biological problems are now solved to that extent that it is possible to have a commercially viable operation. Lake classification, management techniques, improved genetic strains and a better understanding of the ecosystem have made this possible.

SESSION D

AQUACULTURE IN CANADA - NATIONAL PERSPECTIVE

Chairman - I. Pritchard
Rapporteur - D. Reid

The following is a summary of the chairman's presentation of "Problems and policies affecting aquaculture research and development".

Policy should relate to the general needs of the various communities within aquaculture. In established policies the objectives used as the basis for policy development are sometimes not as well defined as policy itself. In turn, the research used as the basis for establishing objectives may also not be clear.

Policy development in Canada has been affected by the recent trend to decentralization within the government agencies. "In some cases this has perfected the parts without necessarily developing the whole."

Policy development can have a significant effect without a significant expenditure of funds, as is now being shown by beneficial effects in such areas as fish health regulations.

In order to have the proper conditions for policy development it is necessary to have an insight into the technical criteria and social concerns in the area being addressed. In this regard it is necessary to define the groups within aquaculture which will form the basis for decisions. In preparing policy some difficulty is encountered in setting singular policies in view of the diversity of these communities and their particular problems. One example cited would be the different requirements of seaweed growers and salmon ranchers.

In looking at Canadian policy it is worthwhile summarizing development in other countries. In the United States, one such aquaculture development plan has been developed for the national oceanic and atmospheric administration (NOAA). In the NOAA Plan the transdisciplinary nature of the planning process indicated the preferred approach to the task would be on a systems analysis basis.

In Canada we have not institutionalized aquaculture as a separate area but have instead tried to integrate it into existing agencies and programs. Ideally, existing organizations should integrate a total approach of preservation - conservation - restoration - augmentation and culture. Existing organizations however have been given mandates which do not include each of these areas.

Present and future policy strategies include:

1) Integrated resource use

   Flexibility in policy has prevented development from being stymied by using a single policy.

2) External advocacy (response to specific requests or problems)

   Government should wait for the definition of problems before acting since anticipation of problems may lead to development of the wrong policy.

3) Research and development planning

   One strategy may be possible, utilizing a systems approach, in different regions.

4) Follow international development

   If we are unable to develop our own technology or if we can buy it more readily, then we should do so.

5) Policy statements

   More groups and agencies are now starting to develop policy statements on aquaculture including those involved in food policy, fisheries management and education.

   One model suggests that aquaculture policy should ensure:

   - meeting basic needs of people
   - self-reliance
   - symbiosis between people and environments
   - preservation of biological and cultural diversity.

In addition to specific aquaculture policy issues there are several related policy issues touching on aquaculture. The present "make or buy" policy in Canada's science policy may help development of aquaculture. In the United States a prerequisite for aquaculture development success includes the early involvement of industry and government together.

A definition of how funding for development can be achieved is needed before policy can be determined. In some cases the lack of support for the Fisheries and Marine Service has restricted this.

Among the outstanding issues still to be resolved are disease compensation, coastal zone management and the conditions for licensing.

In looking to the future, candidate food systems based upon aquaculture may include those shown on Fig. 1. Achievements in these systems will require a multi-disciplinary approach utilizing input from the areas as shown in Fig. 2.

Discussion by the workshop members suggested several dimensions be added to the basis for future policy direction.

In the biological base itself, we may want to reexamine the choice of species existing

policies have been based on. Included in this would be a look at the more basic aquaculture techniques used in other countries and a thorough examination of the potential of our native species before we consider exotics.

One suggestion was made that Canada's more flexible approach to policy may have assisted in making aquaculture advances in the Maritimes. Direction which may have resulted from fixed policies was instead replaced by initiatives suited particularly to local situations.

While some advantages may be attributed to Canada's flexible approach to policy development, it was pointed out that there is a very great need to have formal recognition of aquaculture as a legitimate area within existing management policy concurrent with a commitment to support its activities to some degree. In the commercial area, there is a need for recognition of aquaculture as a legitimate food industry. In many cases direct financial support may not be needed since further defining the role of aquaculture would allow it to work within existing programs. Classification of commercial aquaculture enterprises into the same category as agriculture for tariff or financial purposes would be one such benefit of role definition.

Within the aquaculture community organizations similar to the aquaculture association of Nova Scotia and the Ontario Trout Farmers Association are starting to collectively address the needs of aquaculturists.

Increased interest in aquaculture may result from future shifts in emphasis from a traditional meat and poultry base to more fishery products. This interest would be enhanced by the availability of more fresh fish in the marketplace.

Several of the workshop attendees observed that since the Fisheries Research Board no longer carries out its former role that an effort should be made to relay research concerns directly to regional directors within the Department of Fisheries and the Environment. To this the original speaker added that input for policy development from the regions is certainly possible and is not necessarily solely the role of Ottawa. While the Fisheries Research Board Act still exists, with responsibilities passed on to the Fisheries and Marine Service, it was noted that this has had a negative effect generally on some aspects of private sector development.

Dr. Allsopp was asked to comment on the relationship between Canadian aquaculture research and development efforts and international programs. His comments have been paraphrased in the following five paragraphs.

International programs involving research and development in aquaculture can have increasingly indicative and important policy and directional implications for our perspectives in Canada.

Much of the basic biological studies now applied in hatcheries and ecosystems management for salmonid species or principles developed in molluscan culture studies have had direct application in areas overseas where Canada's foreign aid programs provide assistance.

1. Sea ranching (Atlantic and Pacific salmon)
2. Sea pen rearing (tuna, trout, coho and chinook)
3. Prairie pothole (rainbow trout)
4. Intensive factory farms (trout, raceways, etc.)
5. Off-bottom shellfish production (oysters, mussels, scallops)
6. Crustacean cultures (lobsters)
7. Marine plants (Irish moss, dulse)
8. Solar tanks and aquaria (Tilapia)
9. Farm ponds monoculture (carp, trout)
10. Polyculture

Fig. 1. Candidate food systems based upon aquaculture.

Fish nutrition and feed technology (energetics, feed formulation, etc.)

Fish health (infective, physiologic, ecological-stress related, neoplastic, toxic, etc.)

Reproductive physiology (endocrinology, etc.)

Genetics and stock selection techniques

Fish biology (egg production, nursery care, etc.)

Chemistry (water, feedstuffs, etc.)

Farm management economics

Engineering (farm design and equipment)

Products processing and marketing (quality control, etc.)

Fig. 2. Scientific inputs required for aquaculture operations.

From such an international perspective therefore it may be worthwhile recognizing the complementary influence on personnel; research and development studies and the relevance of basic research findings which have a mutually stimulating influence on research activities in Canadian and overseas laboratories. Though the Canadian programs of aquaculture are therefore intended to satisfy

local objectives, they also provide additional opportunities. Common among these are training linkages, research applications, information dissemination and feedback exchanges, and the testing of equipment and procedures under different environmenal conditions, species and field use. One may cite the developments in such research findings as salmon pituitary for breeding, fish tranquilizers and fish disease vaccines as areas which have had wide application and impact in other countries of the world, though seeming to have limited application on the Canadian scene.

It should also be recognized that though it is not a prime aim of the federal, provincial or university research institutions, they do provide the resource personnel for such foreign aid programs and international agencies to which Canada contributes. Accordingly, it may be well for the Canadian International Development Agency and the International Development Research Centre to make adequate provision for funding staff replacements, training and institutional building in such institutions as are involved in such programs (e.g., provincial universities) of aquaculture promotion.

Finally, it should be realized that the development prospective of aquaculture in relation to world food supplies may provide an added dimension of possibilities in Canada when intensive mechanized systems for processing certain species (possibly mussels, and rough fish) are developed. As current custodians of the Canadian aquatic resources the obligation to maximize its production and use in the context of world needs may well have long-term implications. This could be an important contribution in global environmental conservation and food production enhancement in which Canada has made a major contribution in other food areas of world food supplies.

SESSION E

AQUACULTURE IN CANADA - WHAT DO WE DO NEXT?

Chairmen - J.W. Zahradnik
- I. Neish
- P. Montreuil

The objective of this session was to identify future biological research and development needs as seen from the perspective of working level researchers. Only biological inputs were considered in this analysis.

The omission of such factors as: processing, marketing, efficient control, economic analysis, labor, capital, etc., does not mean they are unimportant, just outside the scope of this workshop. It is recognized that these factors are very important for any aquaculture development.

Problems in the aquaculture of species now commercially cultured and species for which a commercial interest currently exists were considered in terms of the scientific inputs of: life history studies, environmental requirements, culture systems, seed, feed/nutrition, mortality control/diseases, genetic improvements/stock selection and prototype testing. The assumptions for priorizing these scientific inputs or factors were:

- that additional research and development was required from a biological point of view to provide a 90% probability of culture success, and/or potential for significant breakthrough.

For each species, key problems were identified and the need for additional research and development determined. Marine aquaculture (Table 1) and freshwater aquaculture (Table 2) were treated separately.

It should be pointed out the priorities are most meaningful within a species and should not necessarily be used to compare species. Furthermore, the priorities should only be viewed in terms of the assumptions outlined above. For example, a low priority does not necessarily mean that there are no significant problems associated with that factor. It may mean that at this time insufficient information is available to make a decision possible.

The research and development priorities are summarized below for each scientific input.

Life history studies

Life history studies are a necessary basis for the culture of any species. The life histories of most species considered for culture in Canada are reasonably well known. Significant exceptions do, however, exist. It was decided that:

- The life histories of important marine macrophytes and microphytes should be studied.

- Lack of knowledge of specific aspects of the life history of certain species e.g., smoltification and migration of Atlantic salmon in hindering aquaculture development. Such problems should be addressed.

- Manipulation of life histories e.g., induced growth (sterilization or maturation) with hormone treatments could significantly alter the potential of certain species.

Environmental requirements

Defining the environmental requirements of a species in specific culture systems is of high priority for the development of aquaculture. There is insufficient knowledge of environmental requirements of any species cultured. It was decided that:

- Environmental requirements such as temperature, light, water quality, density, etc. should be determined for the most important cultured species in relation to the particular systems in which they are cultured. Such information is necessary if efficient facilities are to be designed.

- The interactions between environmental requirements and other factors such as nutrition, genetics and diseases should be determined for the major cultured species.

Culture systems

Culture systems must be designed in concert with the advantages and limitations of the Canadian environment. Cage culture in the warmer waters of

the Pacific, pothole culture in the eutrophic prairie ponds, ocean ranching in the Maritimes and recirculation and waste heat utilization schemes in the cold waters are examples of such an approach. It was decided that:

- Integration of aquaculture with other industries such as farms or thermal power generating sites should be considered.

- Culture systems such as recirculation units, solar heat units, etc. that make more efficient use of energy should be developed.

- Innovative culture systems, such as polyculture with indigenous species, that make better use of resources should be considered.

Seed/reproduction

Reliable sources of seed are one of the main foundations of commercial aquaculture. Aspects of reproductive physiology of most of the main cultured species in Canada are sufficiently known to make controlled culture biologically possible. It was decided that:

- Additional work on mollusc larvae production, lobster egg production and salmon maturation in salt water should be carried out.

- Sources of disease-free fingerlings are not a biological research and development problem but the lack of such sources presently inhibits commercial aquaculture development.

Feed/nutrition

Feed and nutrition studies are particularly important for lobsters and tuna and for the salmonids which are now being commercially cultured it was decided that:

- The development of a Canadian fish feed industry should be encouraged.

- The nutritional requirements of salmonids as well as other species are imperfectly known and further diet development depends upon their elucidation.

- Diets should be developed for specific life stages and environmental conditions.

- The relationships between diets and such factors as disease resistance, environmental conditions and post-release performance should be determined.

- Alternate plant and animal protein sources indigenous to Canada should be evaluated as replacements for traditional fish feed components.

Mortality control/disease

Problems associated with mortalities due to disease and stress are most significant in intensive culture operations. Lobsters and most salmonids suffer severe losses due to diseases. It was decided that:

- The new fish health protection regulations while undoubtedly beneficial in the long term have created problems of seed supply in the present.

- Vaccines for fish should be developed but it is probable that this will be possible with only a limited number of infectious agents. Basic immunological studies are required for this development.

- The relationship between diseases and other factors such as environmental stress, nutrition, genetic improvement, etc. should be examined.

Genetic improvement/stock selection

Genetic improvements are long term and have greatest benefits when culture conditions are well known and complete control can be maintained over all aspects of production. It was decided that:

- Genetic diversity of important species should be preserved by identifying and protecting different genetic strains. Ocean ranching and other stock enhancement programs have the potential to cause the loss of unique and possibly beneficial small gene pools by "flooding" the population with stocked individuals. The genetic diversity necessary for future genetic improvements would be lost.

- Systematic stock evaluations in culture conditions should be implemented in order to identify and take advantage of naturally occurring genetic superiority. Stock selection has already proved beneficial for oyster production (Malpeque disease resistance), carp and trout production and seaweed production.

- Selective breeding for improved performance (e.g., growth, viability, food conversion ability, etc.) of the most important species over which significant environmental control can be maintained should be carried out.

Prototype systems

Development of prototype systems is essential for the development of an aquaculture industry. Problems associated with such factors as marketing, investment capital, labor supply, efficient control, economic analysis, etc. cannot be solved unless prototype systems are available. Prototype systems also provide important feedback to the biological aspects of production. It was decided that:

- There should be a development of prototype culture systems that can be used to provide input to the various factors necessary for commercial development.

Table 1. Identification and priorization of biological research and development inputs having the highest potential of producing a significant breakthrough in the culture of salt water organisms important to Canada.

Organism	Input: Life hist.	Envir. reqmts.	Culture systs.	Seed	Feed	Mortal. control	Genetic improv.	Proto. testing
Oysters (*Crassostrea gigas* and *C. virginica*)	Medium	Low	Medium	High	Medium	Medium	Low	Low
Oysters are the most valuable of the marine organisms cultured in Canada. The primary biological problem associated with oyster production is the lack of adequate stable supplies of seed.								
Coho salmon (*Oncorhynchus kisutch*)	Medium	Medium	Low	Medium	High	High	Medium	Low
Although this is the species most abundantly and successfully cage-cultured, mortality control from disease (especially furunculosis and kidney disease) and local blooms of spiculated diatoms needs greatest attention. Improved smolt quality, early salt water transformation, development of brood stock, optimizing lower cost rations, and adequate means for inventory taking remain as areas requiring advancement.								
Rainbow trout (*Salmo gairdneri*)	Low	Medium	Medium	High	High	Medium	High	Medium
Cage culture of rainbow trout is practiced primarily in the Maritimes. There is need for identification and production of superior stocks more suitable for local conditions, new diets for use in salt water, adequate supplies of disease-free fingerlings.								
Tuna (*Thunnus thynnus*)	Low	Medium	Medium	Low	High	Medium	Low	Low
There is a limited culture of wild caught tuna in Nova Scotia to improve growth and market acceptability. This type of operation is unlikely to expand. The major requirements are nutritional involving the development of adequate fatness (adding 25% by weight) and desirable flesh color for impounded adults.								
Atlantic salmon (*Salmo salar*)	Medium	High	Low	Low	Medium	High	High	Medium
Cage culture of Atlantic salmon is possible only in a very few restricted areas of the Maritimes because of the cold. The major problems impeding development of ocean ranching are associated with the slow growth of the smolts in the cold water, the period of introduction to sea water and the low level of returns from the ocean.								
Brook trout (*Salvelinus fontinalis*)	Low	Medium	Low	Medium	Low	Medium	High	Medium
Successful cage culture of brook trout in salt water is hampered by their delayed onset of salinity tolerance; their propensity to mature at a small size; lack of adequate supplies of high quality seed stocks; losses due to diseases, particularly vibrio.								
Chinook salmon (*Oncorhynchus tshawytscha*)	Low	High	Low	High	Medium	High	Medium	Low
This species is probably a better species then coho by virtue of a large egg and ready transfer to sea as underyearlings, but an acute shortage of eggs exists and the present diets for salt water rearing are considered restrictive for full growth potential.								

Table 1. continued

Organism	Input: Life hist.	Envir. reqmts.	Culture systs.	Seed	Feed	Mortal. control	Genetic improv.	Proto. testing
Lobster (*Homarus americanus*)	Low	Low	Medium	High	High	Medium	Medium	Medium
Lobster culture is possible as total culture from egg to market and as enhancement culture or further grow-out of small captured lobsters. Techniques of seed production in culture systems are required as well as better diets and methods of preventing losses due to diseases.								
Macrophytes (e.g., *Chondrus crispus*)	Medium	High	High	Low	Low	Low	High	Medium
Commercial culture of macrophytes requires further information on the effect of environmental variables, such as light, temperature, nutrients, etc. on the rate of biosynthesis of the desired end products (e.g., agar-agar, carrageenon, protein, etc.). Identification and use of special strains or clones for higher production is essential.								
Microphytes	Medium	High	High	Low	Low	Low	High	Medium
Commercial microphyte production is impeded by lack of knowledge on basic aspects of life histories and on the effect of environmental variables on production. Specially selected strains or clones could provide a major breakthrough.								
Scallops (*Patinopecten caurinus* and *Placopecten magellanicus*)	High	High	High	Medium	Medium	Low	Low	Medium
The biological and economic potential of scallop production requires assessment. The supply of seed either from the wild or from hatcheries needs development.								
Chum/pink salmon (*Oncorhynchus keta* and *O. gorbuscha*)	Low	Low	Low	Medium	Medium	High	Medium	Low
These species naturally go to sea as fry, but their early rearing poses dietary problems and greater disease susceptibility.								
Mussels (*Mytilus edulis*)	Medium	High	High	Low	Low	Low	Low	Low
There is a need for identification of good production sites and a definition of the environmental factors associated with those sites.								
Brine shrimp (*Artemia salina*)	Medium	High	Low	High	Low	Low	Low	Low
Brine shrimp are produced in Canada at present and the commercial harvest of *Artemia* eggs from saline lakes in Saskatchewan will probably develop into culture as some control is exerted over natural production. Major constraints are a lack of knowledge of the environmental requirements for growth and reproduction, and factors which affect the hatching success of eggs.								

Table 1. continued

	Input							
	Life hist.	Envir. reqmts.	Culture systs.	Seed	Feed	Mortal. control	Genetic improv.	Proto. testing
Amphipods (*Gammarus* sp.)	Low	High	High	Low	Medium	Low	Low	Low
The culture of amphipods is at an early stage in Canada. Studies on life history, environmental requirements and culture systems for two species, the estuarine *Gammarus lawrencianus* and freshwater *G. lacustris*, are in progress. Initial work on growth, feed conversion and flesh quality of rainbow trout fed *G. lacustris*, and on harvesting methods for *G. lacustris* have been done.								
Major research problems are nutrition, the environmental requirements for amphipods as well as their algal or detritus food, and the design of cultural systems which interface amphipods with predators or other polyculture species.								

Table 2. Identification and priorization of biological research and development inputs having the highest potential of producing a significant breakthrough in the culture of freshwater organisms important to Canada.

	Input							
	Life hist.	Envir. reqmts.	Culture systs.	Seed	Feed	Mortal. control	Genetic improv.	Proto. testing
Rainbow trout (*Salmo gairdneri*)	Low	Medium	Medium	Low	High	High	High	Low
Rainbow trout are widely cultivated in Canada in systems ranging from prairie pothole lakes to raceways and hatcheries. The optimum environmental conditions in temperature, light, density, etc. have not been established in culture systems making design of facilities and projections of production difficult. Significant losses due to diseases occur in intensive culture. Improvement of growth and viability by nutritive and genetic means would be of substantial benefit.								
Brook trout (*Salvelinus fontinalis*)	Low	Medium	Medium	Low	High	High	High	Low
In eastern Canada the production of brook trout rivals that of rainbow trout. There is a need to reduce losses due to diseases by producing disease-resistant strains and developing vaccines. The environmental optima have not been determined making design of facilities and projections of production difficult. Advances in nutrition and selective breeding could significantly improve growth rates in the cool Canadian waters.								
Lake trout (*Salvelinus namaycush*)	Low	High	High	Low	High	High	High	Low
Lake trout are cultured for sport and commercial fishing purposes. The improvement of growth and survival after release by means of selective breeding, improved nutrition in the hatchery, and improved disease control are desirable.								
Walleye (*Stizostedion vitreum*)	Medium	High	Medium	Low	Medium	Medium	Low	Low
Walleye are stocked in commercial fishing lakes in Canada while they and other percids are being cultured for food in other parts of the world. Cannibalism in culture and poor survival in the wild after release are major problems.								

Table 2. continued

	Input							
	Life hist.	Envir. reqmts.	Culture systs.	Seed	Feed	Mortal. control	Genetic improv.	Proto. testing
Whitefish (*Coregonus* sp.)	Medium	High	Medium	Low	Medium	Medium	Low	Low
Whitefish are now cultured for commercial fishing stock enhancement and there is intense interest in their potential in commercial aquaculture. The poor survival of released fish could be ameliorated by culturing the fish for a longer period of time and releasing larger fish. The methods for such culture are not well defined.								
Carp (*Cyprinus carpio*)	Low	Low	Low	Low	Low	Low	Medium	High
Small numbers of common carp are cultured for ethnic markets in Canada. Sufficient information on carp culture is available from other regions to make the lack of prototype testing the major problem identifiable at this time. Importation and evaluation of new strains already genetically improved could have an important effect on production.								
Pike (*Esox* sp.)	Low	Medium	High	High	Low	Low	Low	Low
Pike and muskellunge are cultured for sport fish stocking in Ontario and Quebec. Adequate techniques are not available for control of reproduction or for efficient rearing of young in confinement.								
Arctic char (*Salvelinus alpinus*)	Medium	High	Medium	Medium	Medium	Medium	Medium	Medium
Commercial interest has been expressed in the culture of Arctic char, particularly in northern Canada where native groups would be benefitted. The immediate needs are to determine the environmental optima for species and develop adequate culture systems.								
Bass (*Micropterus* sp.)	Medium	High	Medium	High	Low	Low	Low	Low
Bass and other centrarchids are cultured for sport fishing in ponds, primarily in southern Ontario. Adequate techniques are not available for complete control over reproduction. Diseases and parasites may cause a significant loss of production.								
Baitfish (*Cyprinidae* sp.)	Medium	Medium	High	Low	Low	Medium	Low	Low
There is a limited amount of baitfish culture in Canada. The primary need is for a better definition of environmental requirements and an improvement of culture systems.								
Crayfish (*Oroconectes* sp. and *Astacus* sp.)	Low	High	High	Low	Medium	Low	Low	Low
Crayfish culture is practiced in the United States and in European countries with climates similar to that of Canada. The main problems are related to the relatively slow growth rate and small size in the cool waters. Culture strategies require development.								

APPENDIX A

LIST OF ATTENDEES AND AFFILIATION

Dr. D.E. Aiken
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Dr. S. Slinger
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Guelph, Ontario

Dr. J. Stewart
Fisheries & Marine Service
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Halifax, Nova Scotia

Dr. A. Sutterlin
Fisheries & Marine Service
St. Andrews Biological Station
St. Andrews, New Brunswick

Dr. John W. Zahradnik
Department of Bio-Resource Engineering
Faculty of Agriculture
University of British Columbia
Vancouver, British Columbia

[1] Present address: Fisheries & Marine Service
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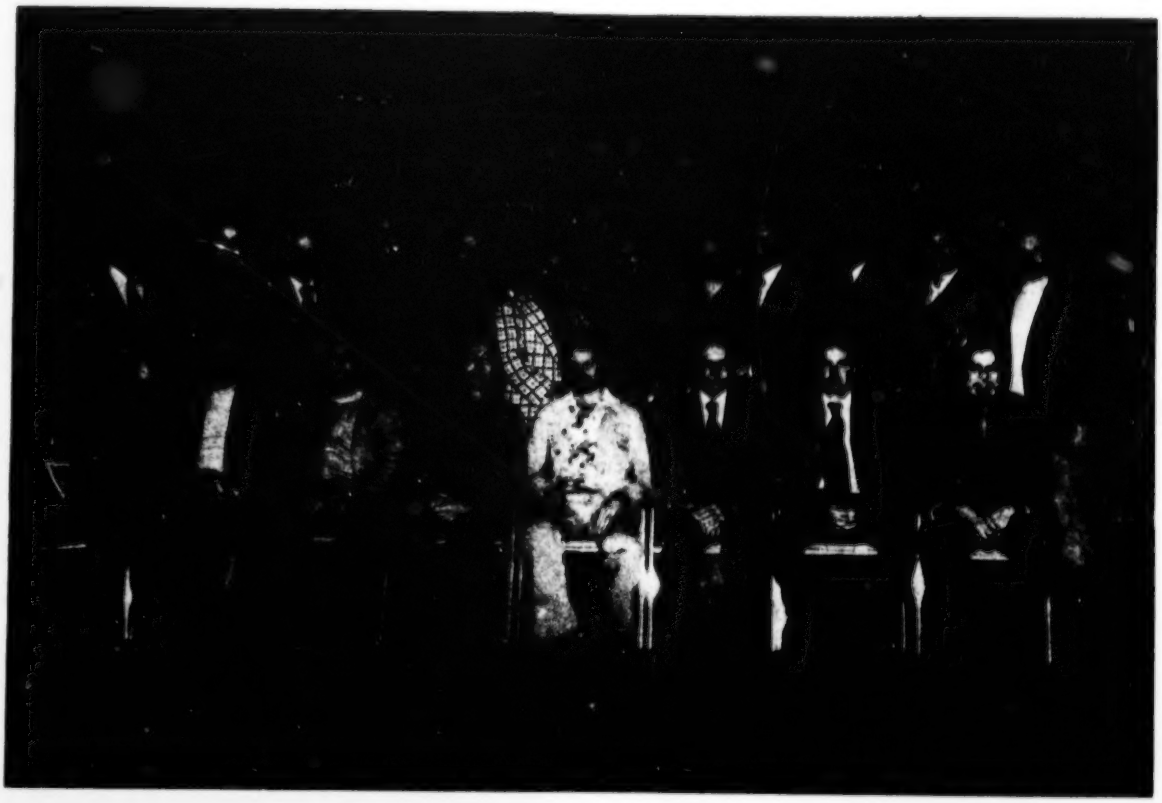
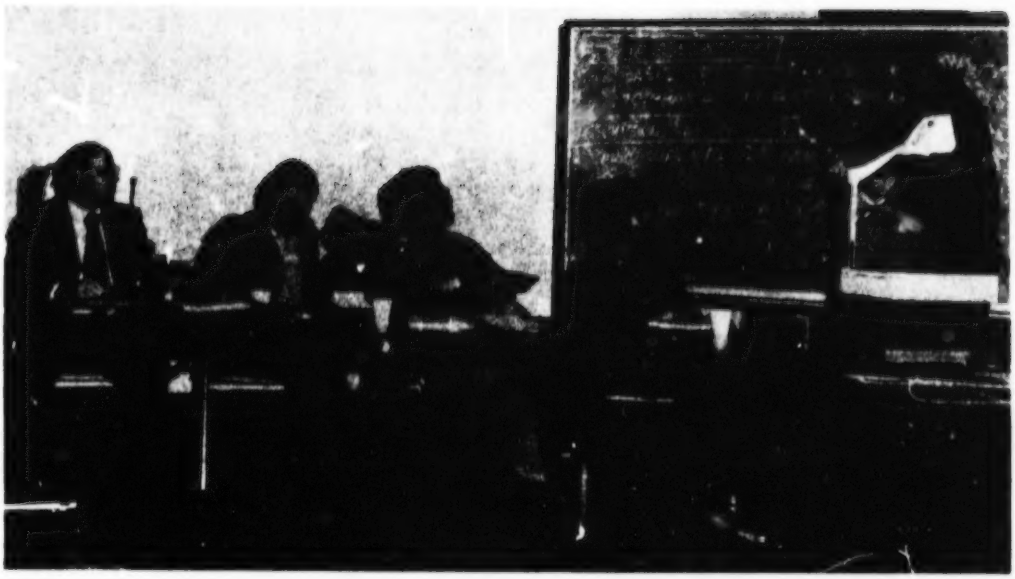
Halifax, Nova Scotia

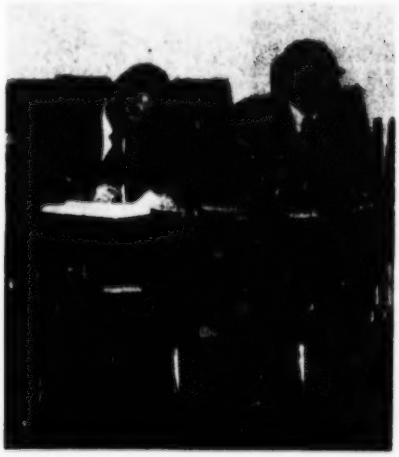
[2] Unable to attend.

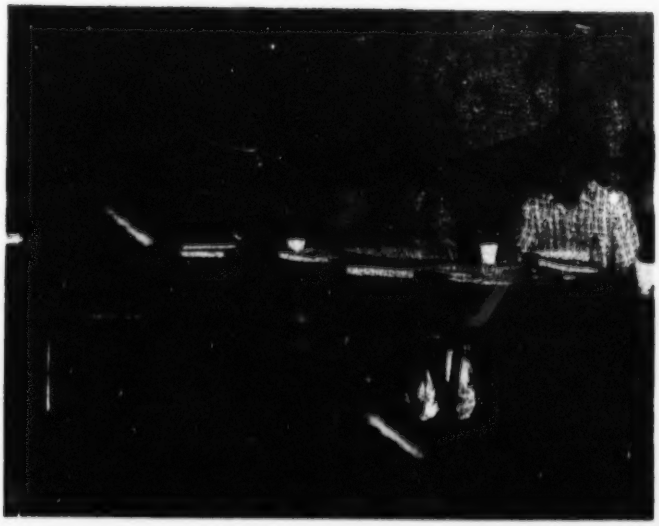


Top row, left to right: J. Stewart, H. Kreiberg, I. Pritchard, P. Ihssen, D. Reid, D. Aiken, A. Sutterlin, E. Donaldson, J. Castell, B. Allsopp, K. MacKay, R. Saunders.

Bottom row, left to right: I. Neish, S. Slinger, R. Drinnan, R. Brett, B. Ayles, P. Montreuil, D. Groves, J. Zahradnik.







APPENDIX B

WORKSHOP AGENDA

November 29

0845	Registration	Large seminar room, Freshwater Institute
0900	Introduction	Dr. B. Ayles
0910	Session A - Status of Aquaculture Research and Development Programs in Canada	
		- verbal summaries of distributed material outlining activities of various groups across the country
	Chairman	- Dr. R. Brett
1130	Session B - Status of Aquaculture Production in Canada	
		- verbal summaries of distributed material summarizing aquaculture production in Canada
	Chairman	- Dr. R. Brett
1330	Session C - Aquaculture in Canada - What do we know?	
		- regional focal sessions to identify the scientific and technical base for aquaculture in each region. Open discussions guided by the chairman.

Atlantic:

Chairman	- Dr. J. Stewart
Rapporteur	- Dr. R.E. Drinnan

Freshwater

Chairman	- Dr. S. Slinger
Rapporteur	- Dr. J. Mathias

Pacific:

Chairman	- Dr. E. Donaldson
Rapporteur	- Dr. D. Groves

November 30

0900 Session C - Rapporteurs' reports from regional sessions

Location - Large seminar room

1000 Session D - National Programs and Problems

- an open discussion of problems and policies affecting aquaculture research and development

Location - Large seminar room

Chairman - Dr. I. Pritchard

Rapporteur - D. Reid

1100 Session E - Aquaculture in Canada - What should we do next?

- regional focal sessions to identify prospects for aquaculture in the regions and to develop long- and short-term research priorities. Open discussions guided by the Chairman.

Atlantic:

Chairman - Dr. I. Neish

Freshwater:

Chairman - Dr. P. Montreuil

Pacific:

Chairman - Dr. J. Zahradnik

1500 Closing remarks - Dr. B. Ayles, Dr. R. Brett

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